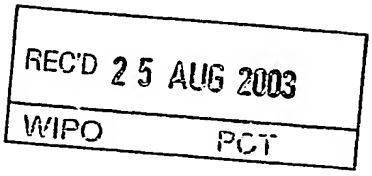

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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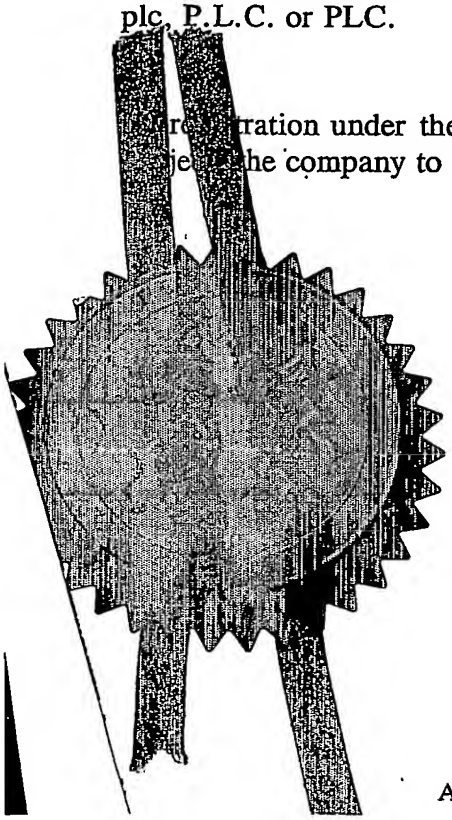

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01JUL02 E729984-1 D02651
P01/7700 0.00-0215152.0

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(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

561GB

2. Patent application number
(The Patent Office will fill in this part)

0215152.0

- 1 JUL 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Renishaw plc
New Mills
Wotton-under-Edge
Gloucestershire, GL12 8JR

Patents ADP number *(if you know it)*

2691002

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

Probe Or Stylus Orientation

5. Name of your agent *(if you have one)*

R D Cavill et al

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Renishaw plc, Patent Department
New Mills
Wotton-under-Edge
Gloucestershire
GL12 8JR

Patents ADP number *(if you know it)*

79026500 1

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
-	-	-

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*
-	-

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	9
Claim(s)	0
Abstract	0
Drawing(s)	7 or 7

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Priority documents	0
Translations of priority documents	0
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	0
Request for preliminary examination and search *(Patents Form 9/77)*	0
Request for substantive examination *(Patents Form 10/77)*	0
Any other documents *(please specify)*	0

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 01.07.2002

AGENT FOR THE APPLICANT

12. Name and daytime telephone number of person to contact in the United Kingdom A Iles 01453 524524

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b) Write your answers in capital letters using black ink or you may type them.

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PROBE OR STYLUS ORIENTATION

The present invention relates to the orientation of a stylus of a measurement type probe e.g. as used on a coordinate positioning machine, brought about by the movement of part of the probe whilst inhibiting movement of the stylus part.

Our co-pending application PCT/GB02/02460 filed 13th June 2002 relates to such stylus or probe orientation, and its disclosure is incorporated herein in its entirety by reference. Stylus orientation is also disclosed in prior patent US 4 571 847 and the entirety of the disclosure in that patent is incorporated herein by reference also.

It is common practice to measure a workpiece on a coordinate measurement machine using a probe on a motor driven or manually movable support. The probe produces a signal when touching the surface of a workpiece, this signal is used to record the coordinate position of the stylus. It is often desirable to reorientate a stylus mounted on a measurement probe.

If, for example, it is required to determine the dimensions of a horizontal surface of a workpiece and also a horizontally extending bore in that workpiece, then the stylus may need to be repositioned. There are a number of ways in which this can be done. Possibly a different stylus can be used for each of the surface and bore inspections, or as is desirable the stylus can be repositioned into a new position. Repositioning can be effected by motors within the probe. Alternatively, repositioning can be effected by restraining some part

of the stylus and moving the probe support to reorientate the stylus. A device of this latter type is disclosed in US Patent No. 5,848,477.

Disclosure of another reorientation technique is made in our US Patent No. 4,168,576. That document discloses the reorientation of a probe extension arm relative to an articulating probe head by means of driving the arm into abutment with a fixed object. The arm is mounted on a pivotable joint and is forcibly repositioned about the pivot when driven into the fixed object. One pivotable joint disclosed provides friction so that the newly orientated stylus stem says in position. Another joint disclosed latches the stylus into position. Neither of those joints mentioned is readily separable.

Simple devices are disclosed in US Patent No. 4,523,450 and European Patent No. 0389108. In those documents a stylus ball is pushed into a receptacle to provide calibration of the actual stylus tip position. US 4,523,450 proposes a stylus mounted on a swingable joint which is pushed into a three-faced recess in order to determine its position.

US Patent No. 5,848,477 also discloses a drive control for moving a stylus tip into a recess and then moving the head whilst the tip hopefully remains centred in the recess.

None of the prior art addresses the problem of maintaining the static relation between parts of the various probes or the problem of stylus exchange.

The present invention provides improvements over the prior art.

The invention will now be described with reference to the accompanying drawings, wherein:

Fig 1 shows a coordinate measurement machine for employing embodiments of the invention;

Fig 2 shows a probe assembly and a stylus repositioning device;

Fig 3 shows the probe assembly of fig 2 and a further stylus repositioning device;

Figs 4&5 show probes which are the subject of patent application PCT/GB02/02460;

Fig 6 shows the probe of either fig 4 or 5 and further stylus repositioning device; and

Fig 7 shows a stylus which is a modified version of the stylus illustrated in figs 4&5 together with another stylus repositioning device.

Fig 1 shows a typical coordinate measurement machine 2 capable of moving a probe 10 in X,Y and Z axes. Typically when measuring a workpiece component 5 the probe 10 together with a stylus 30 held in stylus holder 12 is moved towards the surface of the workpiece until a stylus tip 34 touches the workpiece. At that instant the probe 10 produces a signal to stop the movement of the probe and to record the coordinate position of the stylus tip. From this information dimensions of the workpiece can be determined. Desirably all dimensions of the features of the workpiece need to be determined in one operation without moving the workpiece. This can be achieved as described above, either by using different styli, or

reorientating the stylus.

Embodiments of this invention concern the reorientation/repositioning of the stylus by holding a stylus part whilst moving the machine's quill 8 using the motors of the coordinate measurement machine. In Fig 1 the probe support is illustrated in a second position 8'. Stylus 30 is held by a stylus repositioning device 50 whilst the quill is moved from 8 to 8'. This movement will involve adjustments to the probe support in two or possibly three axes. Further reorientation of the stylus holder 12 will, in the example illustrated in Fig 1, enable the dimensions of the three bores in the workpiece 5 to be inspected.

One type of measurement probe arrangement which has a repositionable stylus is illustrated in more detail in Fig 2. The Figure shows a probe head 14 which has the features described in US 4 571 847 the disclosure of which forms part of this application. In brief this head supports movably a probe 10. Stylus 30 is connected to the probe 10, and both probe and stylus are repositionable to a number of selected positions relative to the quill 8.

Probe support 12 may be rotated about axis A and has three sets of roller pairs 120, each pair being engageable with opposite sides of one of a ring of balls 122. Thus a total of six contact points are made and rotational increments of the probe support 12 equal to the angular ball spacing are possible (15 degrees in this case). A similar arrangement is provided for rotation of the probe support about axis B. The balls and rollers are biased into engagement by springs so

that their relative position is maintained in use. The spring bias can be overcome readily for repositioning.

The stylus 30 (together with the probe 10 in this instance) can be repositioned by obstructing the probe support 12 whilst moving the quill 8. Obstruction of the support 12 is brought about in this example by use of a stylus repositioning device 50.

The device 50 is held stationary and has a ball 52 engageable with a receptacle 54 in the probe support 12. When the quill is driven in an arc or spherical path R having a radius r (equal to the distance between the centre of the ball 52 and the axis A) then repositioning of the stylus 30 is possible in x,y&z axes, in this instance in any of the selected 15 degree rotational increments.

A similar head 14,probe 10 and stylus 12 are shown in figure 3. The head is modified such that the receptacle is replaced with a stalk 56 and ball 58. A different stylus repositioning device 503 is shown.

In use the repositioning device 503 for holds the ball 58 whilst movement of the quill 8 in an arc R takes place. This movement is centred about the ball 58. The device 503 comprises a conduit 48 within a body 60. At one end of the conduit is a lip 62 which forms a datum surface for holding the ball 58. Within the conduit 48 there is induced a vacuum which is provided by a vacuum tube 64. The body 60 is mounted to a base 66 which can be fixed to the bed 4 of the coordinate measurement machine 2.

During repositioning, the ball 58 is moved into contact with the lip 62 and a vacuum is generated within the conduit 48. This vacuum holds the ball 58 against the lip 62 whilst the probe support 12 is repositioned about axis A and/or B

Figures 4&5 show a variant of the head 14 shown in figures 2&3. In this variant the stylus 30 is movable about a stylus holder 12' and the probe 10 is fixed in relation to the quill 8.

Figure 4 shows a probe 10 which produces a signal to stop the coordinate measurement machine when stylus tip 34 touches a surface. Also shown is a movable stylus 30 which may swing in any direction by virtue of a universal joint formed between cup-shaped bearing surfaces 25 and ball 24. The stylus holder 12' is normally held in place but is free, when released, to swing in a part-spherical manner to bring the stylus into positions within the limits shown by the feint outlines 30' and 30'' (i.e. greater than hemispherical movement). Optionally the probe assembly includes a kinematic joint 18 connecting the probe 10 and stylus holder 12'.

During measurement ball 24 is held statically in place in contact with bearing surfaces 25 by the attractive force of a magnet 22. An electromagnet 20 is shown also which may provide additional attraction to hold the ball 24 in place. The ball 24 may be made of ferrous material, or a hollow ceramic body filled with ferrous fluent material. Bearing surfaces 25 may be three pads of ceramic material.

As the quill 8 is moved, to reduce friction at the universal joint and thereby to avoid bending moments in the stylus 30, the magnetic attraction between ball 24 and magnet 22 may be reduced by inducing an opposite field in electromagnet 20. Optionally the electromagnet may be pulsed or the current may be alternated to provide vibrations between the support 12 and the ball 24. These vibrations will reduce the friction in the universal joint. An optional air supply 38 is shown for feeding jets 36. These air jets 36 provide a low friction universal joint, when operated. Where an air supply is provided on the machine this may be used to supply pressurised air via conduit 38 to air jets 36 whilst movement of the universal joint takes place. This air supply will cause a fluid film to form between the surface of the ball 24 and the bearing surfaces 25 and will thereby reduce the friction between the two. The fluid film may replace or augment the electromagnetic friction reducing effects mentioned above.

When movement to the correct orientation has taken place the current in the electromagnet 20 may be switched off or reversed, and/or the air supply discontinued. The stylus 30 12 will thus be repositioned and ready for use.

Figure 5 shows a similar probe assembly to that shown in Figure 4. In this arrangement electromagnet 20 and magnet 22 are replaced by a vacuum chamber 42. Vacuum is induced via a conduit 44. In this embodiment a part-spherical bearing surface 46 is provided.

During measurement a vacuum is held in the chamber 42, to hold the stylus 30 in place, in static relation to the stylus support 12'.

When reorientation of the stylus 30 is required the pressure within the chamber 42 is increased so as to reduce the holding force on the ball 24. Once reorientation has taken place the pressure in the chamber 42 is reduced once more. Optionally (not shown) an electromagnet and/or air bearings may be used to reduce friction, as described above. Ball 24 need not be of a magnetic/magnetisable material if a vacuum is used solely.

Figures 6&7 shows two possible modifications of the styli 30 illustrated in figures 4&5 which may be used in order that these styli may be repositionable using the quill 8 as a driving force.

In figure 6 a receptacle 54' similar to the receptacle 54 illustrated in figure 2 is used. A stylus repositioning device 50 is used. The repositioning technique is as described with reference to figure 2. In this instance the path R again has a radius r.

Figure 7 shows another possible modification. A stalk 60 is attached to the stylus 30 and a cylinder 64 is attached to the stalk. The cylinder 64 is engageable with a rotatable stylus repositioning device 507. The device has a vee slot 66 for accepting the cylinder and for holding it by means of magnetism. Repositioning of the stylus is performed by moving the quill 8 as described above in a path R which has a radius r. Movement of the quill about a centre of rotation

coincident with the centre of rotation B' of the device 507 allows further repositioning of the stylus 30 about axis B.

Exchange of one stylus 30 for another into or out of rack 100 (fig 1) is described in detail in PCT /GB02/02460. At any time during an inspection operation the stylus 30 can be repositioned, for example after being knocked accidentally out of place, by reducing the friction between the ball 24 and bearing surfaces 40 or 46. Reducing the friction sufficiently will allow the stylus to hang down vertically or at a known angle. The stylus can then be reorientated to an exact position for example using the device 50 or 507.

The description and claims refer to a vacuum. Herein this word encompasses any fluid pressure which is lower than ambient or a complete vacuum.

The description and drawings relating to figs 4,5,6&7 show a ball and cup type universal joint. However any universal joint having a convexity and an element be to received around the convexity, or a concavity and an element to be received into the concavity will suffice as an alternative. E.g. a large ball (the convexity) nestable within three smaller spaced balls, or a cup (a concavity) as one piece of the joint and three balls in fixed relation to be received into the cup.

Fig 1

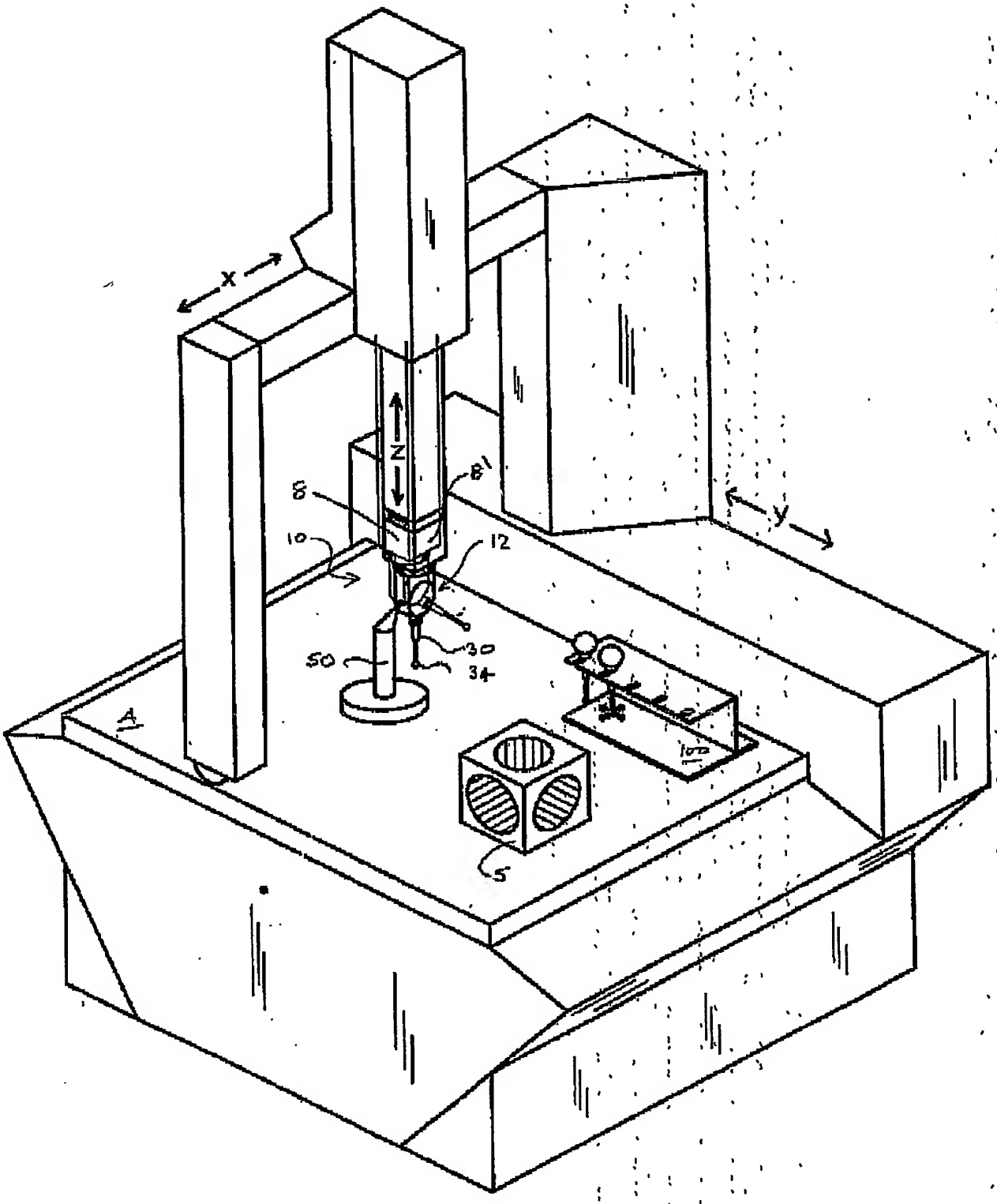

Fig 2

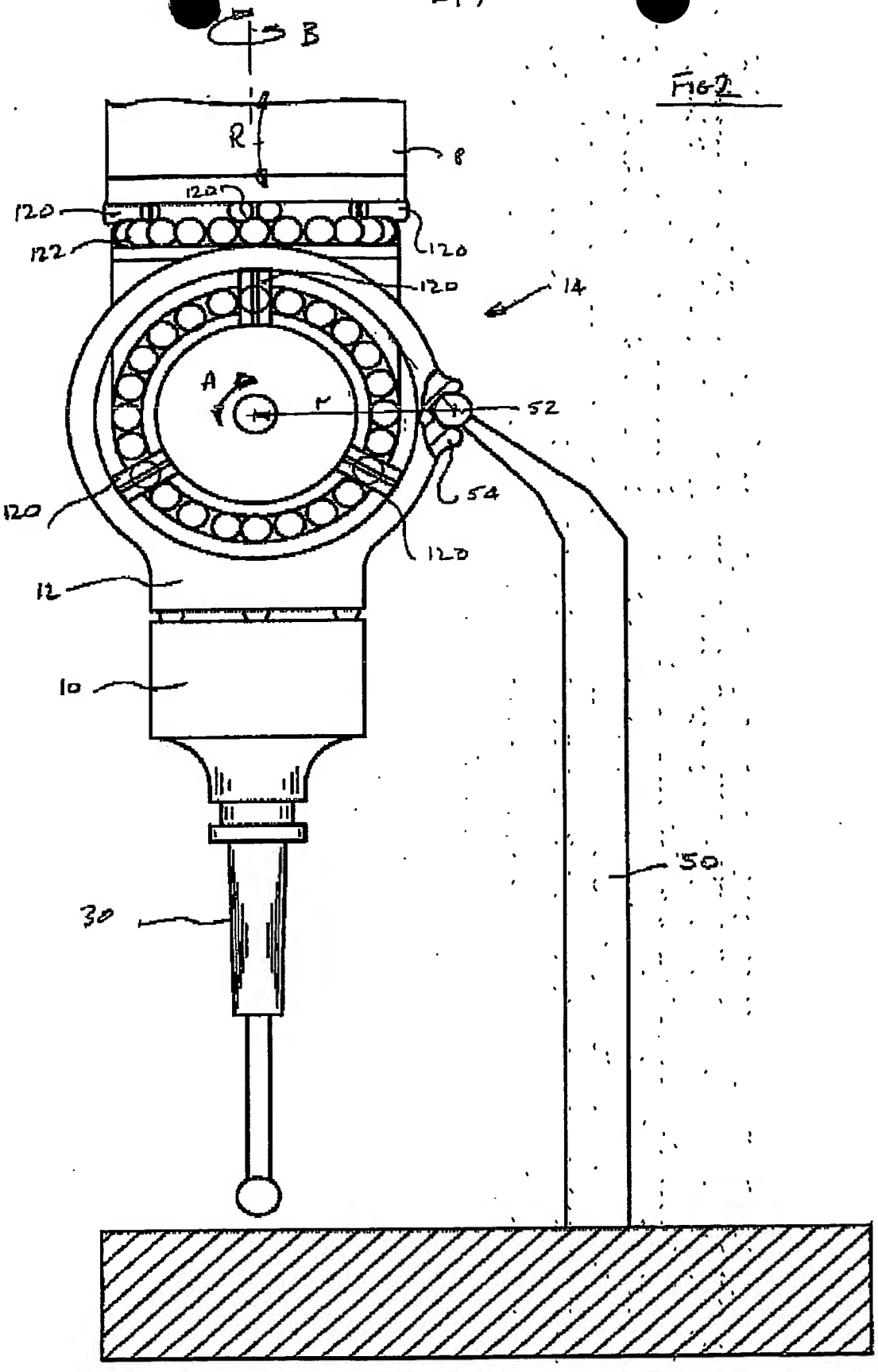

FIG3

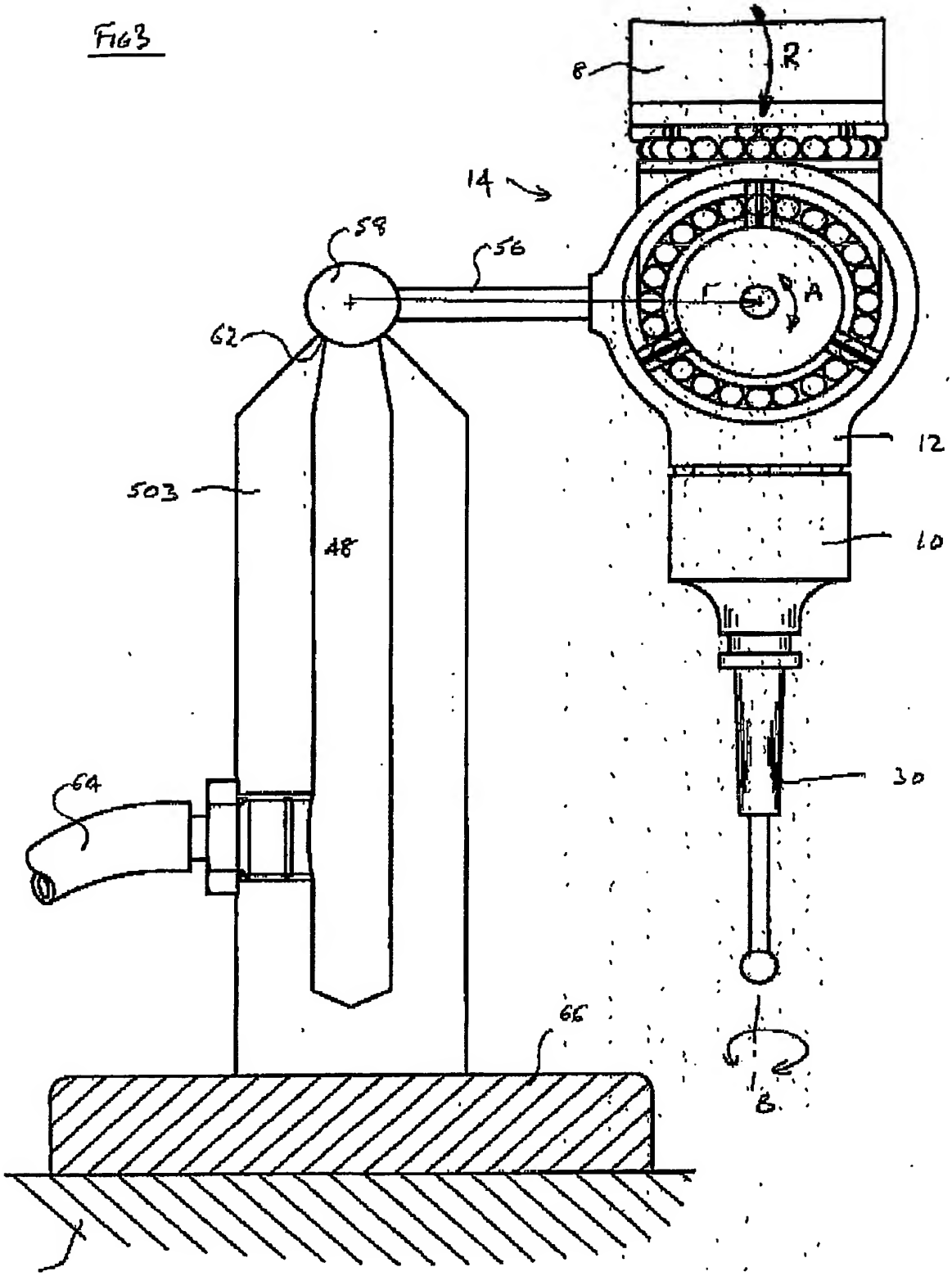

Fig 4

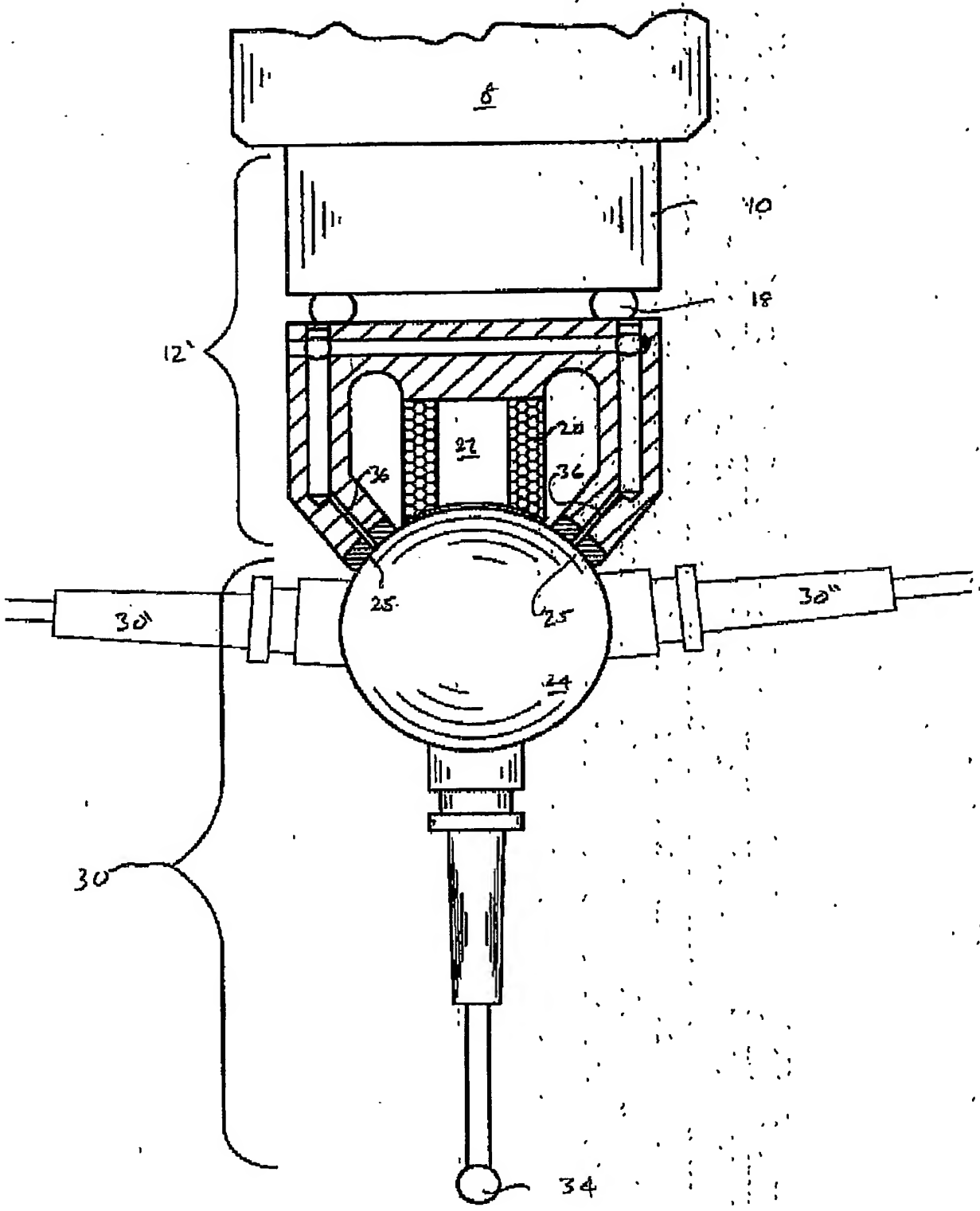

Fig 5

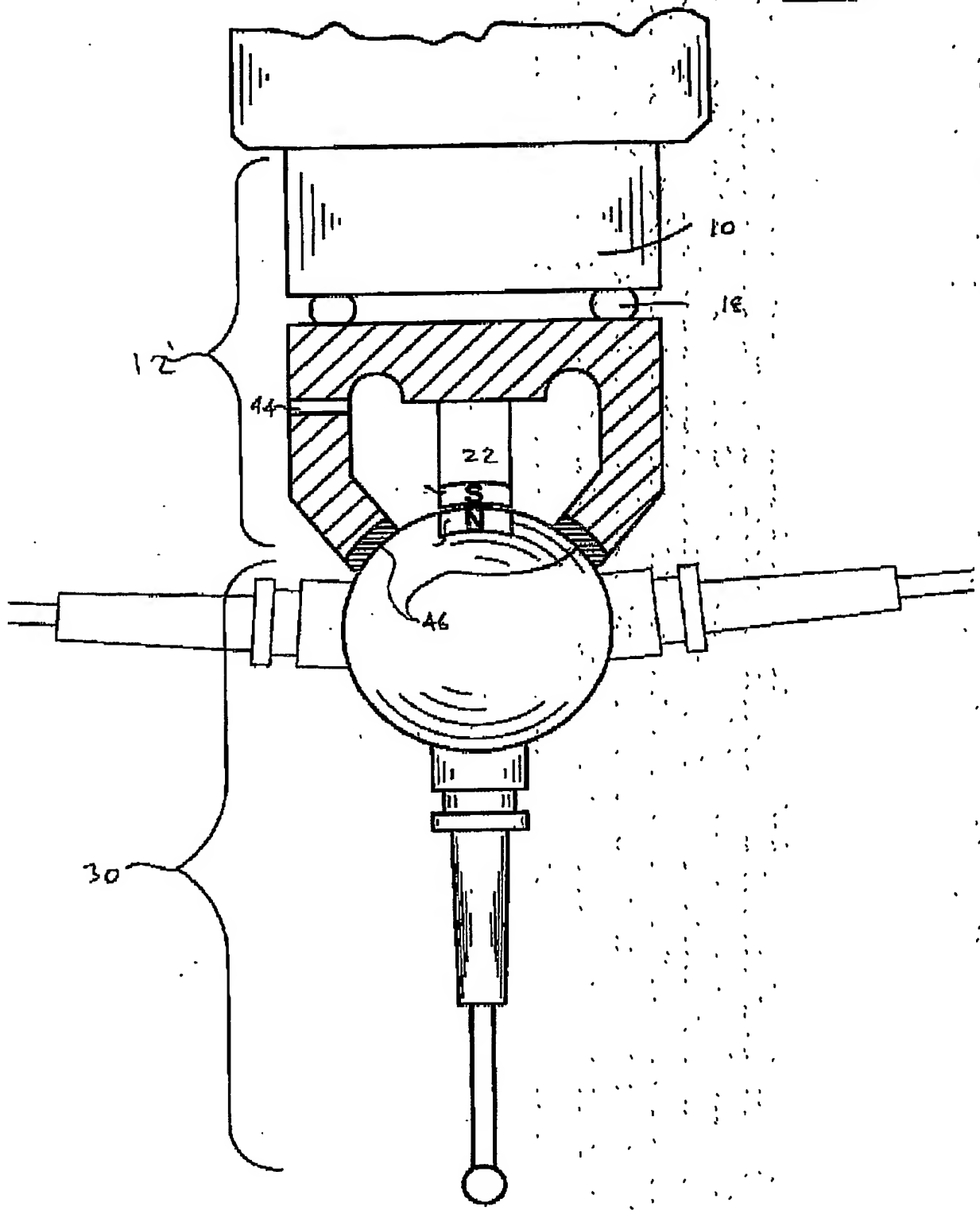

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Fig 6

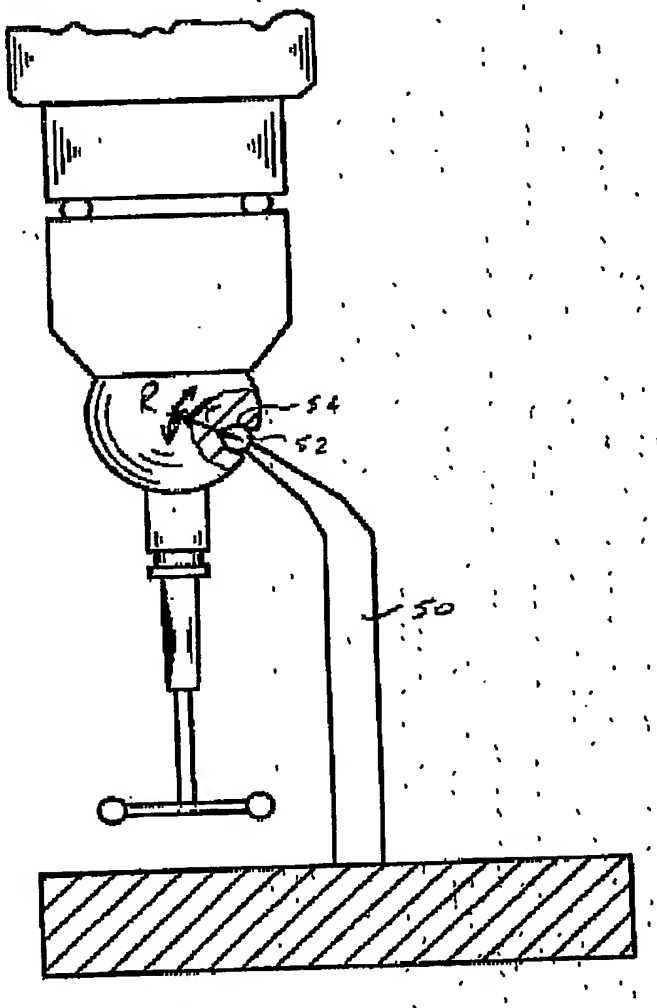

Fig 7